DRP-1-17
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# Dredging Research Technical Notes

## Tropical Storm Database—East and Gulf of Mexico Coasts of the United States

### Purpose

This technical note describes the availability of a database of tropical storm surge elevations and currents produced from the numerical simulation of 134 historically based events that impacted the east and Gulf of Mexico coasts of the United States. The database consists of surge data hydrographs recorded at 486 discrete locations along the east and Gulf coasts and Puerto Rico. Also described are a summary atlas and cross reference tables of storm track and maximum storm surge corresponding to a 246-station nearshore subset of the 486-location database.

This database of information was generated in support of the "Long-Term Fate of Dredged Material Disposed in Open Water" research of the Dredging Research Program (DRP), being conducted by the U.S. Army Engineer Waterways Experiment Station (WES). Although the capability to access these elevation and current time series was developed to provide input to the long-term fate and stability of dredged material model LTFATE, the potential use of such a database goes far beyond the testing of disposal site stability. The database described in this technical note can be used to provide offshore or nearshore boundary conditions for any type of coastal modeling or analysis requiring storm-generated elevation or current data.

### Background

The long-term fate research has been concerned with developing techniques to predict the long-term fate of dredged material after it has been deposited in open water on the ocean floor, that is, to address the question whether a dredged material disposal site, either existing or proposed, is dispersive or nondispersive (Scheffner 1992). If the site is dispersive, an additional capability of the model is to estimate the rate of erosion and fate of the material. Because sediment is primarily eroded and transported as a function of waves and currents, the approach taken was to construct databases of site-specific information that could be used as input to coupled hydrodynamic, sediment transport, and bathymetry change





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models for predicting the long-term behavior of disposal sites. In the DRP, attention was focused on the development of the wave, tidal, and storm surge components.

The wave component of the database provides the capability for generating time series of wave height, period, and direction for any location at which a WES Wave Information Study (WIS) hindcast is available. The wave simulation capability is described in Borgman and Scheffner (1991) and Thevenot and Scheffner (1993). The tidal elevation and current component of the database is described by Westerink, Luettich, and Scheffner (1993) and Scheffner (1994). A database of extratropical storm surge elevation and current hydrographs is currently under development. This technical note describes the tropical storm surge component for the east and Gulf coasts of the United States.

## Additional Information

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## Historic Event Input

The tropical storm database, consisting of surge elevation and current hydrographs corresponding to selected WIS and nearshore stations along the east and Gulf coasts of the United States and Puerto Rico, has been completed (Scheffner and others 1994). The database was constructed by numerically simulating 134 historically based hurricanes that have impacted the eastern and Gulf coasts of the United States during the period 1886 to 1989. The source of data for these simulations is the National Oceanic and Atmospheric Administration's National Hurricane Center's HURDAT (HURricane DATabase), described by Jarvinen, Neumann, and Davis (1988).

The selection of storms from the HURDAT was based on the selection of events that impacted each of eight coastal segments along the east and Gulf coasts of the United States, described by Ho and others (1987). These eight regions were defined to have a homogeneous population of events such that storm parameters associated with events for one location in the segment appear similar to the parameters associated with another location within the segment. A thorough analysis of the selection process and procedures is presented in Ho and others (1987).

The selection of events for inclusion in the database was made by defining a latitude and longitude rectangle encompassing each of the segments. These rectangular regions are shown in Figure 1. The tracks of all 875 events in the 1886-1989 edition of the HURDAT file were examined to determine if they entered the segment rectangle. Of those that did enter

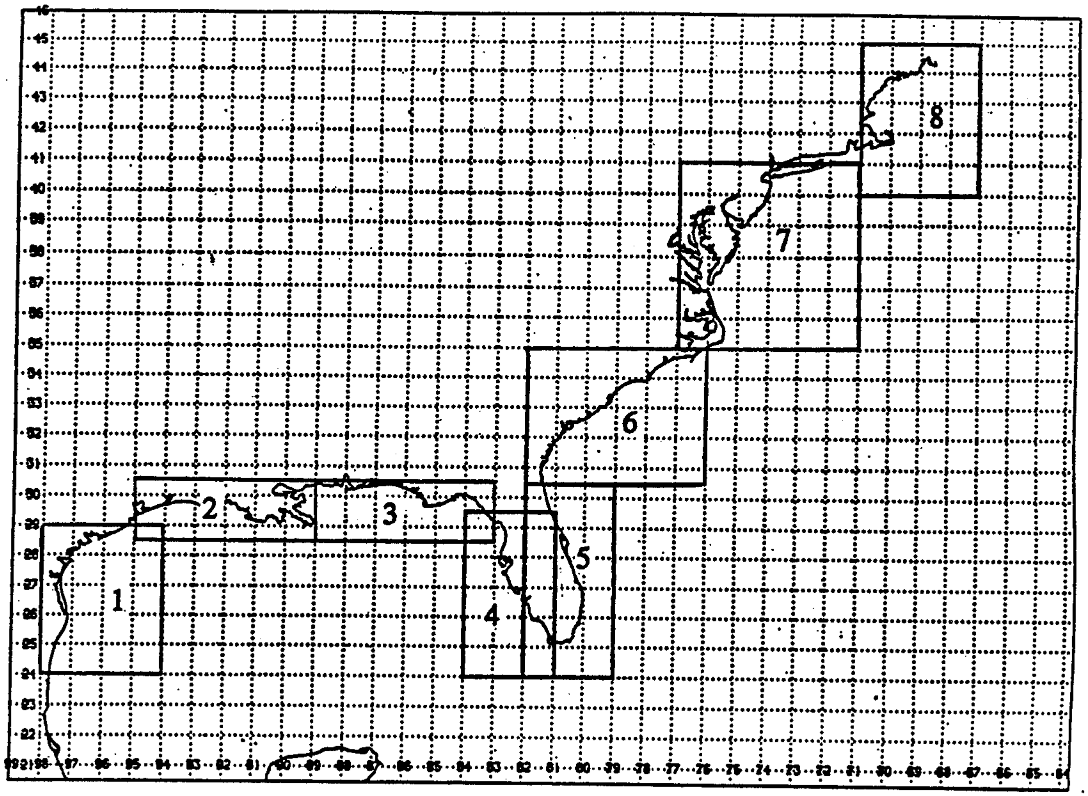



**Figure 1. Coastal segment rectangles**

the rectangle, those events whose minimum central pressure was greater than 995 mb, those whose track was only on the landward side of the rectangle, and those that were far from the shoreline near the seaward boundary were discarded. This process of elimination resulted in the selection of the following number of events associated with each rectangle: 1 - 27; 2 - 35; 3 - 29; 4 - 33; 5 - 55; 6 - 52; 7 - 30; and 8 - 21.

Because many of the events impacted two or more segments, numerous redundancies were identified in the segment-by-segment selection of events. After removing duplications, 134 events were selected for use in the modeling simulation process. These selected events are listed in chronological order in Figure 2 according to date of inception, corresponding HURDAT number, and given name.

## Database Output Station Locations

The goal of this database was to provide boundary condition data for any coastal application requiring either surge elevation or current information along the east and Gulf coasts of the United States. To accomplish this task and have the database remain tractable with respect to memory requirements, discrete locations for archiving data were defined according to two criteria. First, output locations were selected to correspond to the 240 east and Gulf coast WIS stations (Hubertz and others 1993), with

| | | | |
|---|---|---|---|
| 1 | 8/12/1886 | HURDAT # 5 | NOT NAMED |
| 2 | 8/15/1893 | HURDAT # 72 | NOT NAMED |
| 3 | 9/27/1893 | HURDAT # 76 | NOT NAMED |
| 4 | 9/22/1896 | HURDAT # 94 | NOT NAMED |
| 5 | 8/30/1898 | HURDAT # 103 | NOT NAMED |
| 6 | 8/ 3/1899 | HURDAT # 112 | NOT NAMED |
| 7 | 8/27/1900 | HURDAT # 117 | NOT NAMED |
| 8 | 8/ 4/1901 | HURDAT # 127 | NOT NAMED |
| 9 | 9/ 9/1903 | HURDAT # 141 | NOT NAMED |
| 10 | 7/13/1909 | HURDAT # 183 | NOT NAMED |
| 11 | 9/10/1909 | HURDAT # 187 | NOT NAMED |
| 12 | 10/ 6/1909 | HURDAT # 189 | NOT NAMED |
| 13 | 10/ 9/1910 | HURDAT # 194 | NOT NAMED |
| 14 | 8/23/1911 | HURDAT # 196 | NOT NAMED |
| 15 | 8/ 5/1915 | HURDAT # 211 | NOT NAMED |
| 16 | 9/22/1915 | HURDAT # 214 | NOT NAMED |
| 17 | 6/29/1916 | HURDAT # 215 | NOT NAMED |
| 18 | 7/11/1916 | HURDAT # 217 | NOT NAMED |
| 19 | 8/12/1916 | HURDAT # 218 | NOT NAMED |
| 20 | 10/12/1916 | HURDAT # 227 | NOT NAMED |
| 21 | 9/21/1917 | HURDAT # 231 | NOT NAMED |
| 22 | 8/ 1/1918 | HURDAT # 232 | NOT NAMED |
| 23 | 9/16/1920 | HURDAT # 241 | NOT NAMED |
| 24 | 10/20/1921 | HURDAT # 249 | NOT NAMED |
| 25 | 7/22/1926 | HURDAT # 271 | NOT NAMED |
| 26 | 9/11/1926 | HURDAT # 276 | NOT NAMED |
| 27 | 8/ 3/1928 | HURDAT # 289 | NOT NAMED |
| 28 | 9/ 6/1928 | HURDAT # 292 | NOT NAMED |
| 29 | 6/27/1929 | HURDAT # 295 | NOT NAMED |
| 30 | 9/22/1929 | HURDAT # 296 | NOT NAMED |
| 31 | 8/31/1930 | HURDAT # 299 | NOT NAMED |
| 32 | 8/12/1932 | HURDAT # 310 | NOT NAMED |
| 33 | 7/25/1933 | HURDAT # 324 | NOT NAMED |
| 34 | 8/17/1933 | HURDAT # 327 | NOT NAMED |
| 35 | 8/31/1933 | HURDAT # 331 | NOT NAMED |
| 36 | 9/ 8/1933 | HURDAT # 332 | NOT NAMED |
| 37 | 8/29/1935 | HURDAT # 353 | NOT NAMED |
| 38 | 10/30/1935 | HURDAT # 357 | NOT NAMED |
| 39 | 7/27/1936 | HURDAT # 362 | NOT NAMED |
| 40 | 9/ 8/1936 | HURDAT # 370 | NOT NAMED |
| 41 | 9/10/1938 | HURDAT # 386 | NOT NAMED |
| 42 | 8/ 2/1940 | HURDAT # 397 | NOT NAMED |
| 43 | 8/ 5/1940 | HURDAT # 398 | NOT NAMED |
| 44 | 9/16/1941 | HURDAT # 405 | NOT NAMED |
| 45 | 7/30/1944 | HURDAT # 432 | NOT NAMED |
| 46 | 9/ 9/1944 | HURDAT # 436 | NOT NAMED |
| 47 | 10/12/1944 | HURDAT # 440 | NOT NAMED |
| 48 | 8/24/1945 | HURDAT # 445 | NOT NAMED |
| 49 | 9/12/1945 | HURDAT # 449 | NOT NAMED |
| 50 | 10/ 5/1946 | HURDAT # 456 | NOT NAMED |
| 51 | 9/ 4/1947 | HURDAT # 461 | NOT NAMED |
| 52 | 9/20/1947 | HURDAT # 463 | NOT NAMED |
| 53 | 10/ 9/1947 | HURDAT # 465 | NOT NAMED |
| 54 | 9/ 1/1948 | HURDAT # 471 | NOT NAMED |
| 55 | 9/18/1948 | HURDAT # 473 | NOT NAMED |
| 56 | 10/ 3/1948 | HURDAT # 474 | NOT NAMED |
| 57 | 8/23/1949 | HURDAT # 477 | NOT NAMED |
| 58 | 8/20/1950 | HURDAT # 490 | BAKER |
| 59 | 9/ 1/1950 | HURDAT # 493 | EASY |
| 60 | 10/13/1950 | HURDAT # 499 | KING |
| 61 | 8/11/1953 | HURDAT # 520 | BARBARA |
| 62 | 8/28/1953 | HURDAT # 521 | NOT NAMED |
| 63 | 8/28/1953 | HURDAT # 522 | CAROL |
| 64 | 9/23/1953 | HURDAT # 526 | FLORENCE |
| 65 | 10/ 7/1953 | HURDAT # 530 | HAZEL |
| 66 | 8/25/1954 | HURDAT # 535 | CAROL |
| 67 | 10/ 5/1954 | HURDAT # 541 | HAZEL |
| 68 | 8/ 3/1955 | HURDAT # 545 | CONNIE |
| 69 | 8/ 7/1955 | HURDAT # 546 | DIANE |
| 70 | 9/10/1955 | HURDAT # 552 | IONE |
| 71 | 9/21/1956 | HURDAT # 562 | FLOSSY |
| 72 | 6/25/1957 | HURDAT # 565 | AUDREY |
| 73 | 8/24/1958 | HURDAT # 575 | DAISY |
| 74 | 6/18/1959 | HURDAT # 584 | NOT NAMED |
| 75 | 7/23/1959 | HURDAT # 586 | DEBRA |
| 76 | 9/20/1959 | HURDAT # 589 | GRACIE |
| 77 | 8/29/1960 | HURDAT # 597 | DONNA |
| 78 | 9/14/1960 | HURDAT # 598 | ETHEL |
| 79 | 9/ 3/1961 | HURDAT # 602 | CARLA |
| 80 | 9/10/1961 | HURDAT # 604 | ESTHER |
| 81 | 9/30/1961 | HURDAT # 606 | FRANCES |
| 82 | 8/26/1962 | HURDAT # 611 | ALMA |
| 83 | 10/16/1963 | HURDAT # 623 | GINNY |
| 84 | 8/20/1964 | HURDAT # 629 | CLEO |
| 85 | 8/28/1964 | HURDAT # 630 | DORA |
| 86 | 9/28/1964 | HURDAT # 634 | HILDA |
| 87 | 10/ 8/1964 | HURDAT # 635 | ISBELL |
| 88 | 8/27/1965 | HURDAT # 639 | BETSY |
| 89 | 6/ 4/1966 | HURDAT # 643 | ALMA |
| 90 | 9/21/1966 | HURDAT # 651 | INEZ |
| 91 | 9/ 8/1967 | HURDAT # 657 | DORIA |
| 92 | 6/ 1/1968 | HURDAT # 662 | ABBY |
| 93 | 10/13/1968 | HURDAT # 669 | GLADYS |
| 94 | 8/14/1969 | HURDAT # 672 | CAMILLE |
| 95 | 9/ 6/1969 | HURDAT # 676 | GERDA |
| 96 | 5/17/1970 | HURDAT # 688 | ALMA |
| 97 | 7/31/1970 | HURDAT # 690 | CELIA |
| 98 | 9/ 8/1970 | HURDAT # 693 | ELLA |
| 99 | 8/20/1971 | HURDAT # 702 | DORIA |
| 100 | 9/ 5/1971 | HURDAT # 703 | EDITH |
| 101 | 9/ 3/1971 | HURDAT # 704 | FERN |
| 102 | 5/23/1972 | HURDAT # 711 | ALPHA |
| 103 | 6/14/1972 | HURDAT # 712 | AGNES |
| 104 | 9/ 1/1973 | HURDAT # 722 | DELIA |
| 105 | 8/29/1974 | HURDAT # 731 | CARMEN |
| 106 | 8/24/1975 | HURDAT # 739 | CAROLINE |
| 107 | 9/13/1975 | HURDAT # 741 | ELOISE |
| 108 | 5/21/1976 | HURDAT # 746 | SUBTROP 1 |
| 109 | 8/ 6/1976 | HURDAT # 748 | BELLE |
| 110 | 8/29/1977 | HURDAT # 756 | ANITA |
| 111 | 9/ 3/1977 | HURDAT # 757 | BABE |
| 112 | 7/ 9/1979 | HURDAT # 775 | BOB |
| 113 | 8/25/1979 | HURDAT # 777 | DAVID |
| 114 | 8/29/1979 | HURDAT # 779 | FREDERIC |
| 115 | 7/31/1980 | HURDAT # 783 | ALLEN |
| 116 | 8/ 7/1981 | HURDAT # 797 | DENNIS |
| 117 | 11/12/1981 | HURDAT # 805 | SUBTROP 3 |
| 118 | 6/18/1982 | HURDAT # 807 | SUBTROP 1 |
| 119 | 9/ 9/1982 | HURDAT # 809 | CHRIS |
| 120 | 8/15/1983 | HURDAT # 812 | ALICIA |
| 121 | 8/23/1983 | HURDAT # 813 | BARRY |
| 122 | 9/ 8/1984 | HURDAT # 820 | DIANA |
| 123 | 8/12/1985 | HURDAT # 832 | DANNY |
| 124 | 8/28/1985 | HURDAT # 833 | ELENA |
| 125 | 9/16/1985 | HURDAT # 835 | GLORIA |
| 126 | 10/26/1985 | HURDAT # 838 | JUAN |
| 127 | 11/15/1985 | HURDAT # 839 | KATE |
| 128 | 6/23/1986 | HURDAT # 841 | BONNIE |
| 129 | 10/ 9/1987 | HURDAT # 852 | FLOYD |
| 130 | 9/ 7/1988 | HURDAT # 859 | FLORENCE |
| 131 | 11/17/1988 | HURDAT # 864 | KEITH |
| 132 | 7/30/1989 | HURDAT # 867 | CHANTAL |
| 133 | 9/10/1989 | HURDAT # 872 | HUGO |
| 134 | 10/12/1989 | HURDAT # 874 | JERRY |

**Figure 2. Historical tropical storm database**

additional locations prescribed for Puerto Rico. These stations are located at every 0.25 deg of latitude and longitude along the coastline in water depths averaging between 10 and 20 m. Because WIS stations are located at variable distances from the shoreline, 246 additional locations were selected to represent nearshore projections of WIS stations, resulting in a total of 486 discrete locations at which surge elevation and current hydrograph information are archived. Detailed figures of these locations; their respective station numbers, latitude and longitude location, and approximate depth; and the sum of eight primary tidal elevation constituents extracted from the DRP tidal database are given in Scheffner and others (1994).

## Tropical Storm Database

All 134 tropical events selected for the database were simulated in their entirety, with output files initially archived for all 486 WIS and nearshore projected stations. The finite element-based hydrodynamic model ADCIRC-2DDI (Luettich, Westerink, and Scheffner 1992) was used for all storm event simulations. A very large computational domain, shown in Figure 3, is used for modeling the storm events selected as the basis for this database. The modeled area includes the western North Atlantic ocean, the Gulf of Mexico, and the Caribbean Sea. This domain was initially developed for tidal propagation studies (Westerink, Luettich, and Scheffner 1993). However, its implementation for storm propagation has been demonstrated through accurate predictions of both the primary storm surge and the surge forerunner effect (Blain, Westerink, and Luettich, in preparation).

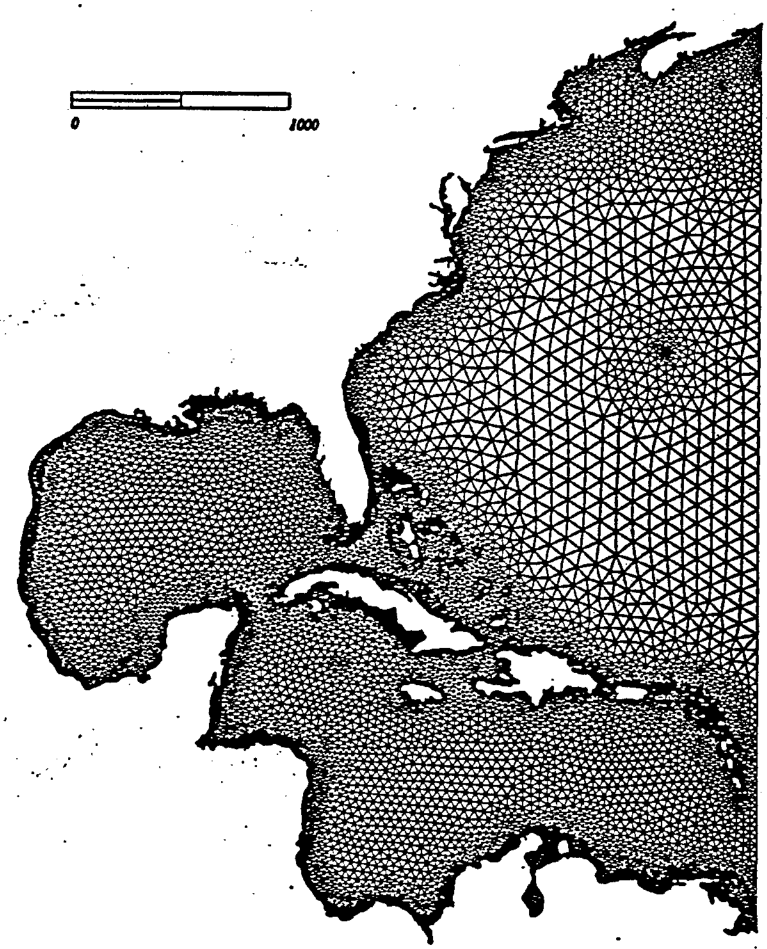



**Figure 3. East coast, Gulf of Mexico, and Caribbean Sea computational domain**

Because each hurricane event does not impact every coastal station, the database described in this technical note and presented in Scheffner and others (1994) was constructed such that surge information was archived only for locations at which a maximum surge elevation of 1 ft (0.3048 m) or greater was computed. To eliminate possible start-up or termination transients or farfield discontinuities that may propagate beyond the edge of the nested PBL model, potential impacted stations were also required to be within a 200-mile (320-km) radius of the eye of the storm. The reported maximum surge was selected as the maximum elevation on the surge water surface hydrograph in a ±6-hr window from the time (nearest hour) when the hurricane eye is nearest to the selected station. A summary of the full database is provided by Scheffner and others (1994), in the form of an atlas of maximum storm surge elevations computed at each WIS/nearshore station subject to the above limitations. The maximum surge atlas and the surge elevation and current database are briefly described below.

## Surge Maximum Elevation Atlas

The atlas of the nearshore spatial distribution of maximum surge elevation was generated as a tool for identifying storms that impacted specific locations along the east and Gulf coast areas and offshore of Puerto Rico. A typical component of the atlas is shown in Figure 4 for Hurricane Bonnie. This figure contains a summary plot of the total storm track according to the information contained in the HURDAT database, as well as a landfall or near landfall map enlargement detailing the spatial distribution of maximum surge magnitudes.

To maximize the readability by reducing the density of information contained in the atlas, surge elevations are reported in decimeters (10 dm = 1 m). For example, the maximum surge for Hurricane Bonnie in Figure 4 is shown to be 13 dm (1.3 m) at the second nearshore station to the east of landfall. The location map and a portion of the station descriptor contained in Scheffner and others (1994) are reproduced as Figure 5. This information is used to identify the station number, location, approximate spring tide amplitude, and approximate depth. For the example shown in Figure 4, the nearshore station can be identified as station 539, located at 93.7569 deg west longitude, 29.6873 deg north latitude, with an approximate spring tide amplitude of 0.8435 m and an approximate depth of 6.5 m.

Cross referencing of the summary database of storm-specific maximum surge elevations for the nearshore gages is provided in the report so that users can determine the spatial alongshore impact of each historic event, and also determine which historic events impacted a specific WIS/nearshore station. This information is presented in a two-sequence tabular form, with the first portion containing the HURDAT storm number and the number of WIS/nearshore stations that were impacted by that storm event (limited to a minimum surge of 1 ft and located within 200 miles of the eye of the event), followed by a tabulation of stations impacted and their respective maximum surge elevations in decimeters. Figure 6

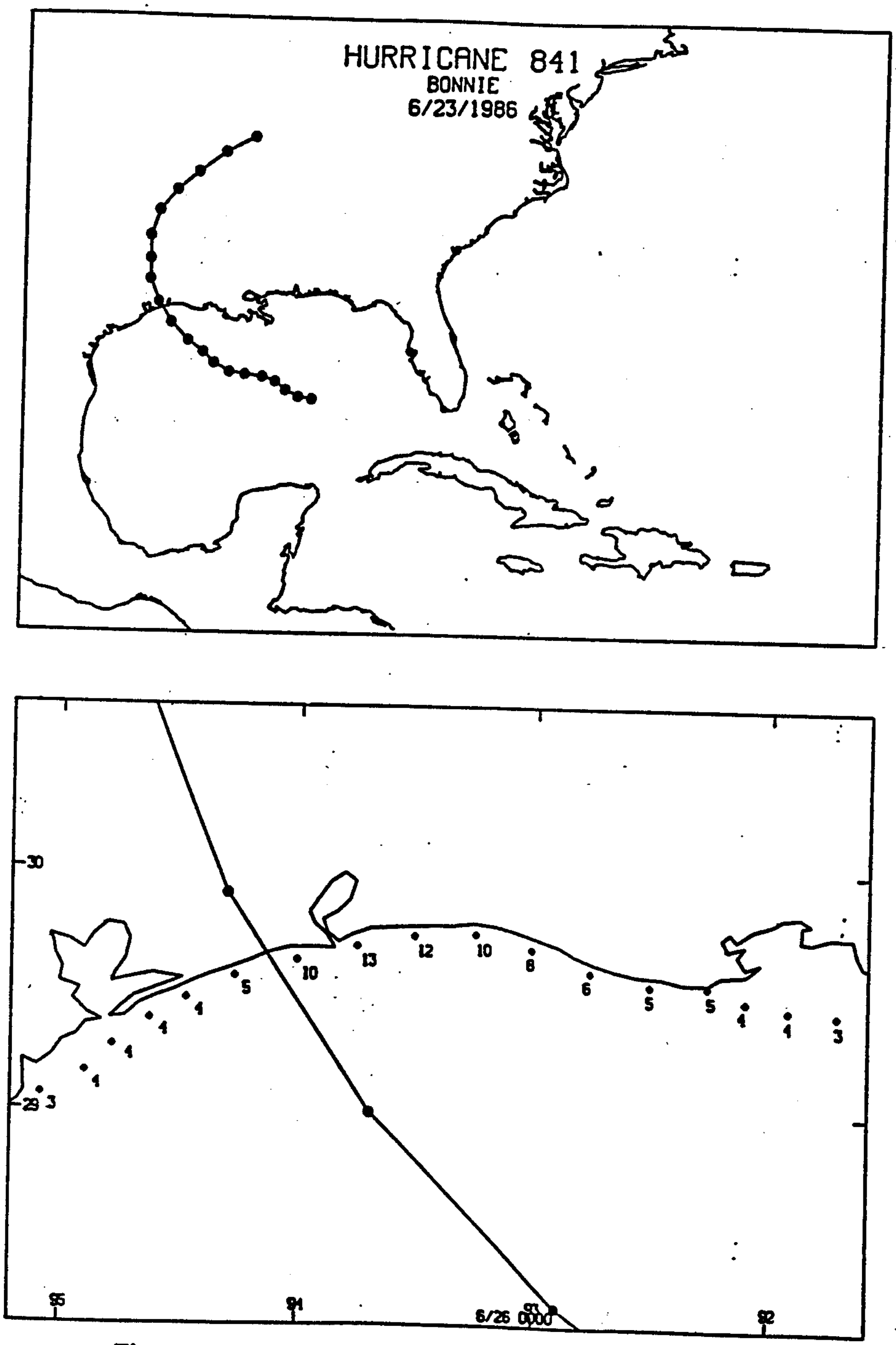
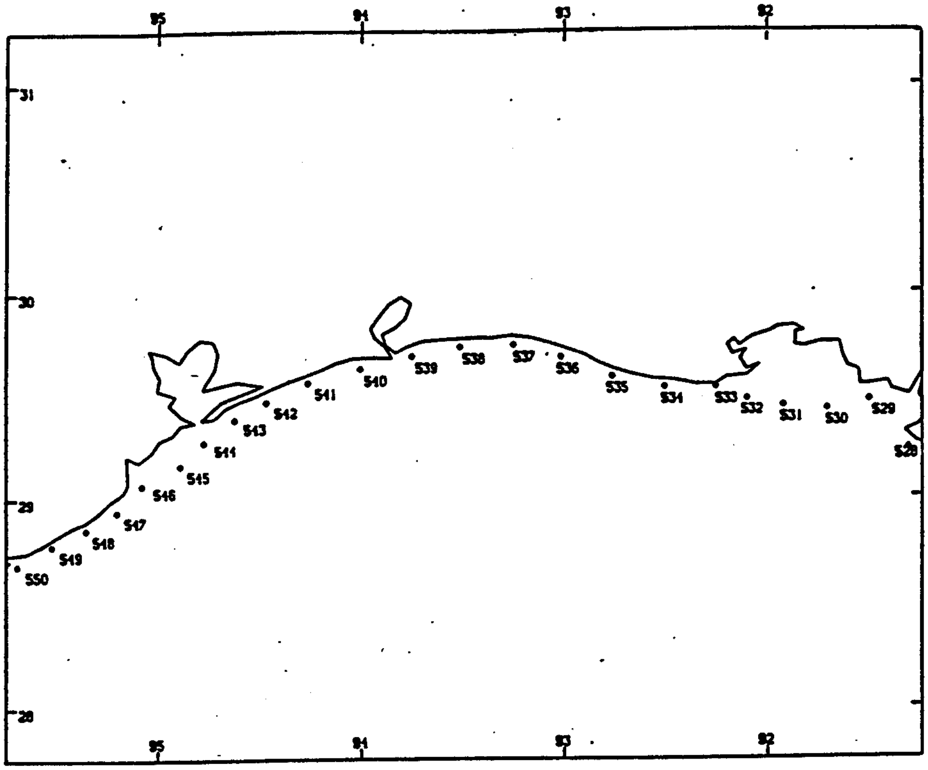



**Figure 4. Track and surge atlas for Hurricane Bonnie**




| Station | Latitude | Longitude | Spring tide Amplitude (m) | Depth (m) |
|---|---|---|---|---|
| 520 | -89.56350 | 29.07680 | 0.45584 | 20.05766 |
| 521 | -89.75130 | 29.23040 | 0.46266 | 9.55403 |
| 522 | -90.00160 | 29.21340 | 0.46487 | 6.98934 |
| 523 | -90.24150 | 29.06830 | 0.47008 | 9.18662 |
| 524 | -90.53360 | 29.21340 | 0.50082 | 8.96870 |
| 525 | -90.76310 | 29.08540 | 0.51362 | 8.78566 |
| 526 | -91.01350 | 29.14980 | 0.55416 | 6.63064 |
| 527 | -91.19080 | 29.16690 | 0.58888 | 5.38724 |
| 528 | -91.31600 | 29.22660 | 0.62024 | 4.62138 |
| 529 | -91.50370 | 29.46550 | 0.64680 | 6.71694 |
| 530 | -91.71230 | 29.42280 | 0.62417 | 4.00000 |
| 531 | -91.92100 | 29.43990 | 0.66267 | 4.00000 |
| 532 | -92.09830 | 29.47400 | 0.68786 | 4.43894 |
| 533 | -92.25480 | 29.53380 | 0.68941 | 4.14046 |
| 534 | -92.50510 | 29.53380 | 0.72280 | 6.21479 |
| 535 | -92.76590 | 29.58500 | 0.76584 | 7.57567 |
| 536 | -93.01620 | 29.67880 | 0.80926 | 6.49206 |
| 537 | -93.25620 | 29.73850 | 0.83335 | 7.12591 |
| 538 | -93.51690 | 29.73000 | 0.84829 | 4.86125 |
| 539 | -93.75690 | 29.68730 | 0.84350 | 6.47503 |
| 540 | -94.00720 | 29.62760 | 0.82655 | 5.76917 |

Figure 5. Sample locator map and station description

presents an extracted example for HURDAT #841 (Hurricane Bonnie). As shown, event 841 impacted 31 WIS/nearshore stations, with station 539 showing a maximum surge of 13 dm.

The second portion of the index presents a tabulation of events that impacted each specific WIS/nearshore station and the surge produced by that storm. For example, Figure 7 presents an example listing for nearshore station 539. As shown in the table, station 539 was impacted by 25 tropical events, with HURDAT #841 producing a maximum surge elevation of 13 dm.

No. Impacted

```
HURDAT STORM 841, # STATIONS-MAX SURGE 31
133- 3 134- 4 135- 4 136- 4 137- 5 138- 7 139- 8 140- 8 141- 7 142- 6 143- 5 144- 5 145- 5 146- 3 530- 3
531- 4 532- 4 533- 5 534- 5 535- 6 536- 8 537-10 538-12 539-13 540-10 541- 5 542- 4 543- 4 544- 4 545- 4
546- 3
```

WIS Station No.

Maximum Surge (dm)

Figure 6. WIS/nearshore stations impacted by HURDAT #841

```
WIS/NEARSHORE STATION 539, # HURDAT STORMS-MAX SURGE 25
  5- 4 117-23 183-10 211-36 232-14 295- 4 310-54 324- 5 397-15 405-23 445-11 565-26 586-10 602-22 690- 8
703- 9 704- 5 722-18 731- 6 809-17 812-24 832- 3 841-13 867-16 874-13
```

Figure 7. HURDAT events impacting WIS/nearshore station 539

The purpose of the atlas and accompanying indexed surge data is to provide a comprehensive listing of storms, their areas of impact, and their intensity as measured by their maximum surge. These data can then be used to identify and access the WIS/nearshore database of tropical events for use as surge elevation and current boundary conditions.

## Surge Elevation and Current Database

The storm elevation and current hydrograph database for both nearshore and WIS stations is available through the Coastal Engineering Research Center at WES. The database consists of 134 separate files, each containing the surface elevation (in meters), the U velocity (east in meters per second), and the V velocity (north in meters per second) at a 15-min

increment for each impacted WIS and nearshore station along the United States east and Gulf coasts and for selected locations offshore of Puerto Rico.

Each file begins with header information containing the HURDAT storm number, start time, duration of the event in hours, hydrograph start time (storm start + 15 min), number of points, and time interval between points. The storm identification data are followed by a tabulation for each impacted WIS or nearshore station, which contains the station identification number and sequential listings of time series of surface elevation, U, and V velocity components. The example header file and station file corresponding to nearshore station 539 are presented as Figure 8. A plot of the data listed in Figure 7 is shown as Figure 9.

As evidenced from the examples presented in this technical note, the tropical event database described in Scheffner and others (1994) is highly informative, easily accessible, and can be used for a variety of preliminary or detailed coastal evaluations of storm intensity and storm impact. This database represents a unique assembly of offshore and nearshore elevation and current time series data that are not available from any single source.

HURRDAT STORM NUMBER: 841
STORM START TIME (YR/MO/DAY/HOUR): 1986/ 6/23/18, #HRS = 114
HYDROGRAPH START TIME (YR/MO/DAY/HOUR): 1986/ 6/23/18.25, #PTS = 456 AT 15.0 MIN INCR
STATION: 539 LONGITUDE,LATITUDE: -93.7570 29.6870
SURFACE ELEVATION (M)

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.001 | 0.001 | 0.002 | 0.003 | 0.004 | 0.005 | 0.006 | 0.008 | 0.009 | 0.011 | 0.012 | 0.014 | 0.016 | 0.019 | 0.022 | 0.025 |
| 0.028 | 0.032 | 0.036 | 0.040 | 0.043 | 0.047 | 0.052 | 0.057 | 0.061 | 0.064 | 0.067 | 0.069 | 0.071 | 0.073 | 0.075 | 0.078 |
| 0.081 | 0.083 | 0.086 | 0.088 | 0.091 | 0.094 | 0.096 | 0.098 | 0.101 | 0.103 | 0.106 | 0.108 | 0.110 | 0.113 | 0.115 | 0.118 |
| 0.119 | 0.120 | 0.121 | 0.121 | 0.121 | 0.121 | 0.122 | 0.122 | 0.123 | 0.125 | 0.126 | 0.128 | 0.130 | 0.133 | 0.135 | 0.137 |
| 0.138 | 0.140 | 0.141 | 0.142 | 0.143 | 0.143 | 0.143 | 0.144 | 0.143 | 0.143 | 0.143 | 0.142 | 0.142 | 0.141 | 0.140 | 0.139 |
| 0.138 | 0.137 | 0.136 | 0.135 | 0.133 | 0.132 | 0.130 | 0.128 | 0.126 | 0.124 | 0.122 | 0.119 | 0.117 | 0.116 | 0.114 | 0.112 |
| 0.110 | 0.109 | 0.108 | 0.107 | 0.106 | 0.106 | 0.106 | 0.106 | 0.107 | 0.108 | 0.109 | 0.111 | 0.112 | 0.114 | 0.115 | 0.116 |
| 0.118 | 0.119 | 0.120 | 0.120 | 0.121 | 0.122 | 0.123 | 0.124 | 0.124 | 0.126 | 0.127 | 0.128 | 0.130 | 0.132 | 0.135 | 0.137 |
| 0.139 | 0.142 | 0.145 | 0.149 | 0.152 | 0.156 | 0.160 | 0.164 | 0.168 | 0.173 | 0.176 | 0.180 | 0.184 | 0.188 | 0.193 | 0.197 |
| 0.202 | 0.207 | 0.211 | 0.216 | 0.220 | 0.225 | 0.229 | 0.233 | 0.237 | 0.240 | 0.243 | 0.247 | 0.250 | 0.254 | 0.256 | 0.259 |
| 0.261 | 0.263 | 0.266 | 0.269 | 0.271 | 0.274 | 0.276 | 0.278 | 0.280 | 0.282 | 0.283 | 0.284 | 0.285 | 0.286 | 0.288 | 0.289 |
| 0.291 | 0.294 | 0.296 | 0.298 | 0.301 | 0.303 | 0.306 | 0.309 | 0.312 | 0.315 | 0.317 | 0.319 | 0.321 | 0.324 | 0.326 | 0.328 |
| 0.329 | 0.331 | 0.332 | 0.334 | 0.336 | 0.338 | 0.339 | 0.340 | 0.340 | 0.340 | 0.340 | 0.340 | 0.340 | 0.339 | 0.338 | 0.337 |
| 0.337 | 0.338 | 0.340 | 0.340 | 0.341 | 0.341 | 0.342 | 0.342 | 0.343 | 0.344 | 0.345 | 0.346 | 0.348 | 0.351 | 0.353 | 0.356 |
| 0.359 | 0.362 | 0.366 | 0.373 | 0.381 | 0.388 | 0.395 | 0.401 | 0.406 | 0.413 | 0.421 | 0.429 | 0.439 | 0.451 | 0.463 | 0.478 |
| 0.494 | 0.511 | 0.533 | 0.557 | 0.584 | 0.618 | 0.661 | 0.708 | 0.762 | 0.826 | 0.897 | 0.972 | 1.049 | 1.121 | 1.187 | 1.244 |
| 1.286 | 1.304 | 1.299 | 1.278 | 1.242 | 1.193 | 1.133 | 1.069 | 1.003 | 0.938 | 0.877 | 0.817 | 0.763 | 0.715 | 0.673 | 0.634 |
| 0.599 | 0.569 | 0.543 | 0.519 | 0.497 | 0.477 | 0.459 | 0.444 | 0.431 | 0.420 | 0.409 | 0.400 | 0.391 | 0.385 | 0.380 | 0.377 |
| 0.375 | 0.373 | 0.368 | 0.360 | 0.351 | 0.340 | 0.329 | 0.318 | 0.308 | 0.297 | 0.286 | 0.276 | 0.265 | 0.255 | 0.244 | 0.233 |
| 0.220 | 0.207 | 0.195 | 0.182 | 0.168 | 0.153 | 0.138 | 0.121 | 0.102 | 0.083 | 0.063 | 0.043 | 0.024 | 0.006 | -0.011 | -0.025 |
| -0.036 | -0.044 | -0.049 | -0.052 | -0.051 | -0.048 | -0.042 | -0.032 | -0.020 | -0.005 | 0.011 | 0.028 | 0.045 | 0.060 | 0.075 | 0.089 |
| 0.102 | 0.114 | 0.124 | 0.132 | 0.138 | 0.142 | 0.144 | 0.143 | 0.141 | 0.137 | 0.131 | 0.123 | 0.114 | 0.104 | 0.094 | 0.083 |
| 0.072 | 0.062 | 0.051 | 0.040 | 0.030 | 0.020 | 0.011 | 0.002 | -0.005 | -0.011 | -0.015 | -0.018 | -0.020 | -0.020 | -0.019 | -0.016 |
| -0.013 | -0.008 | -0.002 | -0.004 | 0.012 | 0.020 | 0.029 | 0.038 | 0.047 | 0.056 | 0.065 | 0.074 | 0.081 | 0.088 | 0.094 | 0.098 |
| 0.100 | 0.100 | 0.099 | 0.096 | 0.091 | 0.086 | 0.080 | 0.073 | 0.066 | 0.059 | 0.052 | 0.045 | 0.039 | 0.033 | 0.027 | 0.022 |
| 0.017 | 0.011 | 0.006 | 0.001 | -0.004 | -0.009 | -0.012 | -0.015 | -0.016 | -0.017 | -0.016 | -0.015 | -0.013 | -0.011 | -0.008 | -0.004 |
| 0.000 | 0.005 | 0.010 | 0.015 | 0.020 | 0.026 | 0.030 | 0.035 | 0.038 | 0.041 | 0.043 | 0.044 | 0.044 | 0.044 | 0.042 | 0.040 |
| 0.037 | 0.033 | 0.028 | 0.023 | 0.018 | 0.012 | 0.006 | 0.000 | -0.006 | -0.012 | -0.018 | -0.023 | -0.028 | -0.033 | -0.037 | -0.040 |
| -0.043 | -0.045 | -0.046 | -0.047 | -0.047 | -0.046 | -0.045 | -0.044 | | | | | | | | |

**Figure 8. Database representation of HURDAT #841, nearshore station 539 (Continued)**

U (EAST) VELOCITY (M/SEC)

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -0.004 | -0.008 | -0.013 | -0.017 | -0.021 | -0.025 | -0.029 | -0.033 | -0.036 | -0.039 | -0.042 | -0.045 | -0.047 | -0.050 | -0.052 | -0.055 |
| -0.057 | -0.060 | -0.063 | -0.065 | -0.068 | -0.071 | -0.073 | -0.075 | -0.077 | -0.080 | -0.083 | -0.085 | -0.087 | -0.089 | -0.090 | -0.092 |
| -0.093 | -0.094 | -0.095 | -0.096 | -0.097 | -0.098 | -0.099 | -0.099 | -0.099 | -0.099 | -0.099 | -0.099 | -0.098 | -0.098 | -0.098 | -0.097 |
| -0.097 | -0.097 | -0.098 | -0.098 | -0.099 | -0.100 | -0.101 | -0.102 | -0.103 | -0.103 | -0.104 | -0.104 | -0.104 | -0.105 | -0.105 | -0.106 |
| -0.106 | -0.107 | -0.108 | -0.108 | -0.109 | -0.110 | -0.112 | -0.113 | -0.114 | -0.114 | -0.115 | -0.115 | -0.116 | -0.116 | -0.116 | -0.115 |
| -0.115 | -0.115 | -0.115 | -0.115 | -0.115 | -0.115 | -0.116 | -0.116 | -0.117 | -0.117 | -0.118 | -0.119 | -0.120 | -0.121 | -0.122 | -0.123 |
| -0.124 | -0.125 | -0.126 | -0.127 | -0.128 | -0.129 | -0.129 | -0.129 | -0.130 | -0.130 | -0.130 | -0.131 | -0.131 | -0.132 | -0.133 | -0.133 |
| -0.134 | -0.135 | -0.136 | -0.138 | -0.139 | -0.140 | -0.141 | -0.142 | -0.143 | -0.144 | -0.144 | -0.145 | -0.145 | -0.145 | -0.145 | -0.145 |
| -0.145 | -0.145 | -0.144 | -0.144 | -0.144 | -0.144 | -0.144 | -0.144 | -0.144 | -0.144 | -0.144 | -0.144 | -0.144 | -0.145 | -0.145 | -0.145 |
| -0.146 | -0.146 | -0.146 | -0.147 | -0.147 | -0.148 | -0.148 | -0.149 | -0.150 | -0.151 | -0.151 | -0.152 | -0.152 | -0.152 | -0.152 | -0.152 |
| -0.152 | -0.152 | -0.152 | -0.152 | -0.152 | -0.152 | -0.152 | -0.152 | -0.153 | -0.153 | -0.154 | -0.154 | -0.154 | -0.155 | -0.155 | -0.155 |
| -0.155 | -0.155 | -0.155 | -0.155 | -0.155 | -0.155 | -0.155 | -0.155 | -0.155 | -0.156 | -0.156 | -0.156 | -0.156 | -0.156 | -0.156 | -0.156 |
| -0.156 | -0.156 | -0.156 | -0.156 | -0.156 | -0.156 | -0.157 | -0.157 | -0.158 | -0.158 | -0.159 | -0.160 | -0.160 | -0.161 | -0.161 | -0.162 |
| -0.163 | -0.163 | -0.164 | -0.166 | -0.167 | -0.169 | -0.171 | -0.173 | -0.175 | -0.178 | -0.181 | -0.184 | -0.187 | -0.191 | -0.195 | -0.199 |
| -0.203 | -0.208 | -0.214 | -0.221 | -0.228 | -0.236 | -0.245 | -0.255 | -0.266 | -0.279 | -0.292 | -0.306 | -0.322 | -0.340 | -0.361 | -0.382 |
| -0.407 | -0.436 | -0.466 | -0.498 | -0.530 | -0.563 | -0.593 | -0.622 | -0.648 | -0.670 | -0.689 | -0.705 | -0.706 | -0.688 | -0.662 | -0.632 |
| -0.595 | -0.552 | -0.508 | -0.464 | -0.425 | -0.394 | -0.365 | -0.333 | -0.302 | -0.274 | -0.245 | -0.215 | -0.184 | -0.152 | -0.120 | -0.086 |
| -0.052 | -0.017 | 0.017 | 0.048 | 0.076 | 0.101 | 0.121 | 0.137 | 0.150 | 0.159 | 0.166 | 0.170 | 0.172 | 0.173 | 0.174 | 0.174 |
| 0.173 | 0.168 | 0.163 | 0.156 | 0.149 | 0.142 | 0.135 | 0.130 | 0.125 | 0.122 | 0.120 | 0.119 | 0.120 | 0.122 | 0.125 | 0.128 |
| 0.131 | 0.134 | 0.136 | 0.137 | 0.137 | 0.136 | 0.133 | 0.130 | 0.126 | 0.122 | 0.117 | 0.112 | 0.107 | 0.102 | 0.098 | 0.093 |
| 0.088 | 0.083 | 0.078 | 0.073 | 0.068 | 0.063 | 0.059 | 0.056 | 0.052 | 0.050 | 0.047 | 0.045 | 0.042 | 0.040 | 0.038 | 0.036 |
| 0.033 | 0.030 | 0.027 | 0.023 | 0.019 | 0.014 | 0.008 | 0.003 | -0.002 | -0.007 | -0.011 | -0.015 | -0.017 | -0.019 | -0.020 | -0.019 |
| -0.018 | -0.016 | -0.013 | -0.009 | -0.005 | -0.001 | 0.004 | 0.008 | 0.012 | 0.016 | 0.020 | 0.022 | 0.024 | 0.026 | 0.027 | 0.027 |
| 0.027 | 0.026 | 0.025 | 0.023 | 0.022 | 0.020 | 0.019 | 0.018 | 0.017 | 0.017 | 0.017 | 0.018 | 0.020 | 0.022 | 0.024 | 0.026 |
| 0.029 | 0.031 | 0.033 | 0.035 | 0.037 | 0.040 | 0.043 | 0.045 | 0.049 | 0.052 | 0.056 | 0.060 | 0.063 | 0.066 | 0.069 | 0.072 |
| 0.073 | 0.074 | 0.075 | 0.076 | 0.076 | 0.076 | 0.076 | 0.076 | 0.077 | 0.078 | 0.079 | 0.080 | 0.082 | 0.083 | 0.084 | 0.085 |
| 0.086 | 0.087 | 0.087 | 0.088 | 0.088 | 0.087 | 0.087 | 0.086 | 0.085 | 0.084 | 0.083 | 0.082 | 0.082 | 0.081 | 0.081 | 0.081 |
| 0.081 | 0.082 | 0.083 | 0.084 | 0.085 | 0.086 | 0.088 | 0.089 | 0.091 | 0.093 | 0.094 | 0.095 | 0.096 | 0.097 | 0.098 | 0.098 |
| 0.098 | 0.098 | 0.097 | 0.097 | 0.096 | 0.095 | 0.095 | 0.094 | | | | | | | | |

V (NORTH) VELOCITY (M/SEC)

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -0.002 | -0.004 | -0.006 | -0.008 | -0.010 | -0.012 | -0.013 | -0.015 | -0.017 | -0.018 | -0.020 | -0.021 | -0.022 | -0.023 | -0.024 | -0.025 |
| -0.026 | -0.027 | -0.028 | -0.030 | -0.031 | -0.031 | -0.032 | -0.033 | -0.034 | -0.036 | -0.038 | -0.039 | -0.040 | -0.040 | -0.041 | -0.041 |
| -0.041 | -0.041 | -0.042 | -0.042 | -0.043 | -0.043 | -0.044 | -0.044 | -0.044 | -0.044 | -0.043 | -0.043 | -0.043 | -0.043 | -0.043 | -0.043 |
| -0.043 | -0.043 | -0.044 | -0.044 | -0.045 | -0.045 | -0.046 | -0.046 | -0.046 | -0.046 | -0.046 | -0.046 | -0.046 | -0.046 | -0.046 | -0.047 |
| -0.047 | -0.048 | -0.048 | -0.049 | -0.049 | -0.050 | -0.051 | -0.051 | -0.052 | -0.052 | -0.053 | -0.053 | -0.053 | -0.053 | -0.053 | -0.053 |
| -0.053 | -0.053 | -0.053 | -0.053 | -0.054 | -0.054 | -0.054 | -0.054 | -0.055 | -0.055 | -0.056 | -0.056 | -0.056 | -0.057 | -0.057 | -0.057 |
| -0.058 | -0.058 | -0.059 | -0.059 | -0.059 | -0.059 | -0.059 | -0.059 | -0.059 | -0.059 | -0.059 | -0.059 | -0.059 | -0.059 | -0.060 | -0.060 |
| -0.061 | -0.061 | -0.062 | -0.062 | -0.063 | -0.063 | -0.064 | -0.064 | -0.065 | -0.065 | -0.065 | -0.065 | -0.064 | -0.064 | -0.064 | -0.064 |
| -0.064 | -0.063 | -0.063 | -0.063 | -0.063 | -0.063 | -0.062 | -0.062 | -0.062 | -0.062 | -0.062 | -0.062 | -0.062 | -0.062 | -0.062 | -0.062 |
| -0.062 | -0.062 | -0.063 | -0.063 | -0.063 | -0.063 | -0.064 | -0.064 | -0.065 | -0.065 | -0.065 | -0.066 | -0.066 | -0.066 | -0.066 | -0.066 |
| -0.066 | -0.066 | -0.066 | -0.066 | -0.066 | -0.066 | -0.066 | -0.066 | -0.067 | -0.067 | -0.068 | -0.068 | -0.068 | -0.068 | -0.068 | -0.068 |
| -0.068 | -0.067 | -0.067 | -0.067 | -0.068 | -0.067 | -0.067 | -0.067 | -0.067 | -0.067 | -0.068 | -0.068 | -0.068 | -0.068 | -0.068 | -0.068 |
| -0.068 | -0.068 | -0.068 | -0.068 | -0.068 | -0.068 | -0.069 | -0.070 | -0.070 | -0.071 | -0.071 | -0.071 | -0.072 | -0.072 | -0.073 | -0.072 |
| -0.072 | -0.072 | -0.072 | -0.074 | -0.075 | -0.075 | -0.076 | -0.077 | -0.078 | -0.079 | -0.081 | -0.082 | -0.082 | -0.084 | -0.085 | -0.087 |
| -0.089 | -0.091 | -0.092 | -0.094 | -0.096 | -0.101 | -0.106 | -0.110 | -0.115 | -0.120 | -0.124 | -0.130 | -0.135 | -0.142 | -0.149 | -0.157 |
| -0.165 | -0.175 | -0.185 | -0.195 | -0.204 | -0.210 | -0.215 | -0.222 | -0.224 | -0.224 | -0.225 | -0.227 | -0.224 | -0.218 | -0.211 | -0.204 |
| -0.202 | -0.201 | -0.195 | -0.186 | -0.178 | -0.174 | -0.168 | -0.158 | -0.145 | -0.133 | -0.120 | -0.106 | -0.090 | -0.073 | -0.057 | -0.040 |
| -0.023 | -0.005 | 0.011 | 0.026 | 0.038 | 0.049 | 0.058 | 0.065 | 0.070 | 0.074 | 0.075 | 0.076 | 0.078 | 0.079 | 0.080 | 0.081 |
| 0.079 | 0.075 | 0.070 | 0.065 | 0.061 | 0.057 | 0.054 | 0.051 | 0.049 | 0.047 | 0.046 | 0.045 | 0.045 | 0.046 | 0.047 | 0.047 |
| 0.047 | 0.048 | 0.049 | 0.049 | 0.048 | 0.046 | 0.044 | 0.042 | 0.039 | 0.037 | 0.034 | 0.033 | 0.031 | 0.030 | 0.030 | 0.030 |
| 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.029 | 0.030 | 0.030 | 0.031 | 0.031 | 0.031 | 0.030 | 0.029 | 0.027 | 0.026 | 0.024 |
| 0.022 | 0.020 | 0.018 | 0.014 | 0.011 | 0.007 | 0.003 | -0.001 | -0.005 | -0.008 | -0.011 | -0.014 | -0.016 | -0.017 | -0.017 | -0.017 |
| -0.016 | -0.015 | -0.014 | -0.012 | -0.010 | -0.007 | -0.004 | -0.001 | 0.002 | 0.004 | 0.007 | 0.009 | 0.012 | 0.013 | 0.015 | 0.016 |
| 0.017 | 0.017 | 0.018 | 0.018 | 0.018 | 0.018 | 0.018 | 0.017 | 0.017 | 0.017 | 0.017 | 0.017 | 0.017 | 0.018 | 0.018 | 0.018 |
| 0.018 | 0.018 | 0.018 | 0.018 | 0.018 | 0.018 | 0.019 | 0.020 | 0.021 | 0.022 | 0.024 | 0.026 | 0.028 | 0.029 | 0.030 | 0.031 |
| 0.032 | 0.032 | 0.032 | 0.033 | 0.033 | 0.033 | 0.034 | 0.034 | 0.035 | 0.036 | 0.037 | 0.038 | 0.039 | 0.040 | 0.041 | 0.042 |
| 0.043 | 0.043 | 0.044 | 0.044 | 0.044 | 0.043 | 0.043 | 0.042 | 0.041 | 0.040 | 0.039 | 0.038 | 0.037 | 0.037 | 0.036 | 0.035 |
| 0.035 | 0.035 | 0.035 | 0.035 | 0.035 | 0.036 | 0.036 | 0.037 | 0.038 | 0.039 | 0.039 | 0.040 | 0.041 | 0.042 | 0.042 | 0.043 |
| 0.043 | 0.043 | 0.044 | 0.044 | 0.044 | 0.044 | 0.044 | 0.044 | | | | | | | | |

**Figure 8. (Concluded)**

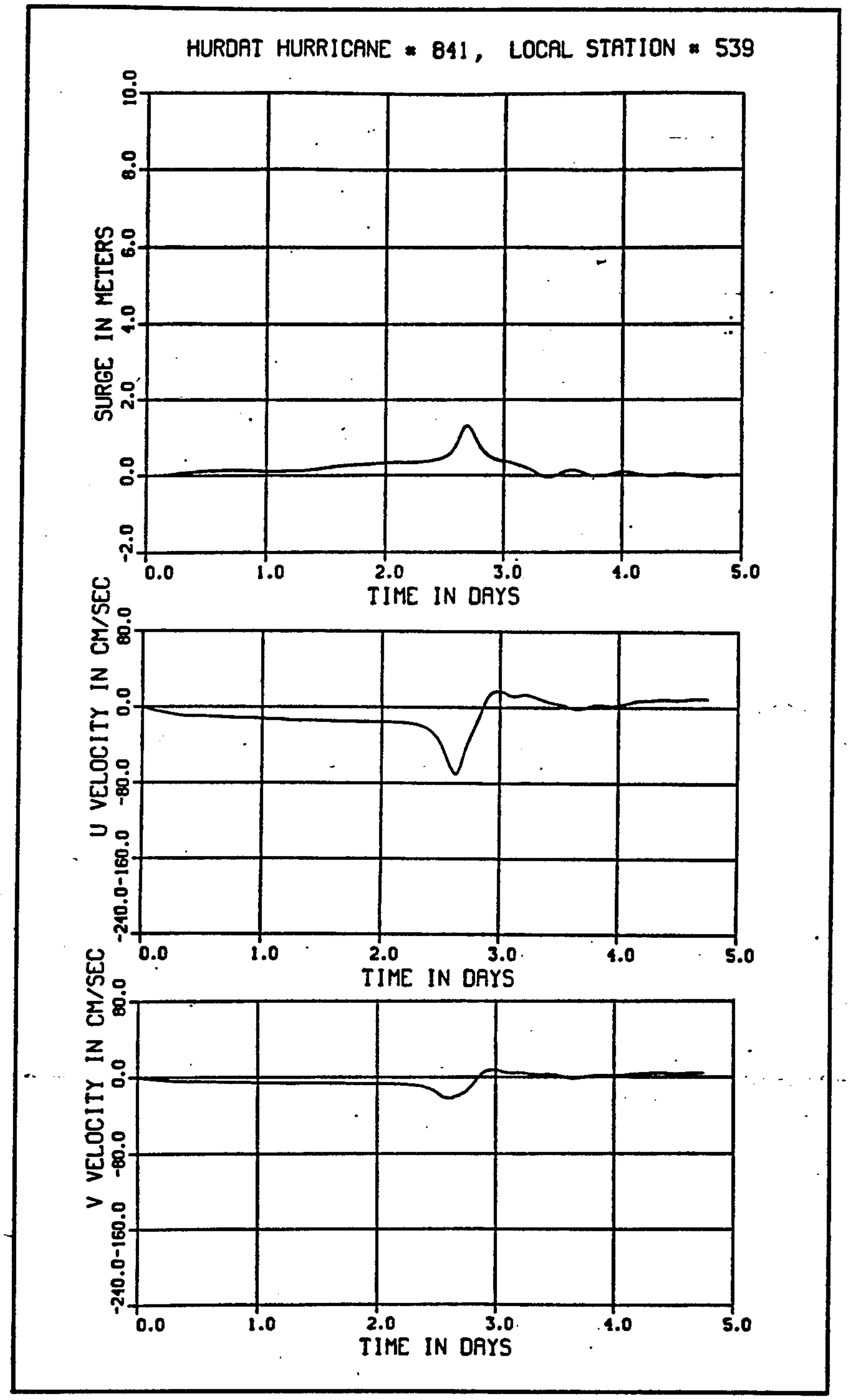



**Figure 9. Hydrograph time series plot of data listed in Figure 8**

## Conclusions

This technical note describes the availability of a database of tropical storm surge elevation and current hydrograph time series that can be used as boundary conditions for evaluating the fate and stability of

dredged material disposed in open water. The data were numerically generated in response to 134 historically based tropical storms that impacted the east and Gulf coasts of the United States. Data are archived at 486 discrete locations along the east and Gulf coasts of the United States and for selected locations around the island of Puerto Rico.

Because tides are not included in the simulations and storm parameters were not optimized to prototype conditions, the selected storms are not intended to be hindcasts of specific events. Rather, the simulated events are intended to approximate a number of historically based storms in order to generate a database of responses that are realistic in both magnitude, duration, and shape.

The tropical storm database for the east coast and Gulf of Mexico described in this technical note satisfies the original goal of the project, that is, to provide boundary condition data for disposal site analysis. Additionally, the database represents a very comprehensive and realistic database of storm data that can be used for a variety of applications in coastal engineering.

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